THE
KANSAS UNIVERSITY
SCIENCE BULLETIN

VOL. XIV, No. 5—OCTOBER, 1922.

(Whole Series, Vol. XXIV, No. 5.)

ENTOMOLOGY NUMBER V.

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THE LIFE HISTORY OF THE TOAD BUG (HETEROPTERA),
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PUBLISHED BY THE UNIVERSITY
LAWRENCE, KAN.

Entered at the post office in Lawrence as second-class matter.

9-4522

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VOL. XIV.] OCTOBER, 1922. [No. 5.

The Life History of the Toad Bug.

Gelastocoris oculatus Fabr. (Gelastocoridæ).*

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INTRODUCTION.

IN MY PAPER on "The Biology and Ecology of the Aquatic Hemiptera"† (pages 49-51) I gave the gist of what was known at the time concerning the habits and life history of the toad bug. Its habitat and feeding habits, together with a brief description of the ovum and fifth nymphal instar were given there.

During the season of 1920 I had an opportunity to gather considerable data relative to these interesting insects. Mrs. Grace Wiley, a student of mine, knowing of my desire to study *Gelastocoris*, sent me a number of living adults from her home in Chanute, Kan., in the autumn of 1919. One of these I kept alive until September, 1920. On May 14, 1920, she sent me a shipment of adults, and again on July 6 another small lot of the bugs. The live insects supplied by Mrs. Wiley thus made possible the notes here reported, and I wish to acknowledge my gratitude to her for her kindness.

THE TECHNIQUE USED IN THE REARINGS.

Tall stenders, or staining jars, of glass about the size of jelly glasses were used. In each of these was placed an inch of sand that had been sterilized by heat. The paired adults were confined in low stenders of various sizes, and the sand searched each day for eggs. The young were isolated in the tall stenders as soon as hatched, for they were cannibalistically inclined, and two young

* Mr. Bueno recognizes this as a new species, *G. acciduus* Ms. I confess I cannot distinguish it from *G. oculatus* Fabr.

† Kansas University Science Bulletin, vol. XI, Dec. 1919; 265 pages, 33 plates.

would get on but a few hours together. The sand was moistened each day, and the jars covered with ground-glass covers. Each nymph was examined daily for molts, which were removed and placed in vials of alcohol or on cotton in small tin boxes, and each instar skin of each insect reared was preserved separately for study. This has provided adequate material for study of structural details of each stage.

We endeavored to determine whether the insects had any choice of soil, by placing them in pans containing sand on one side and sandy loam on the other. Our results were not conclusive. We also used sterilized sandy loam in some of the rearing jars instead of the sand and found it of no advantage.

The insects were fed house flies, plant lice, oscinid flies, cicadellids and many other small insects taken in sweeping the grass upon the campus. Each day the dead carcasses were cleaned out of the rearing jars and freshly killed insects inserted.

Mortality was very high, as a glance at the tables presented below will show, and indicates that some essential factor of their natural habitat was lacking. The fact that 116 nymphs out of 179 died in the first stage, and that they usually succumbed on the date when molting might have been expected to occur, would point to a hazard of ecdysis. An examination of the dates of death of the older nymphs further substantiates this view.

Toward the end of a stadium the nymph always appears plump instead of flat, and so the appearance of the nymph indicates approximately its development. Thus some would become plump in a week and molt; others would develop more slowly.

In spite of the discouragements because of the very high rate of mortality, the tending and study of the rearings were very interesting. Mr. William Hoffman, who assisted me very materially during the latter part of the summer, found the task most absorbing. He fed the nymphs and kept the records with as much interest, care and ingenuity as I could have done, and I desire to acknowledge herewith my indebtedness to him for his services.

HABITAT.

The toad bug is a shore bug, found along the muddy banks of small streams or the sandy beaches by the river. It is a notable example of protective coloration. Specimens taken on muddy banks are dull and slaty grey with indistinct pattern, while those from the sandy beaches are variegated, pebbled and mottled like the sand. Specimens in captivity have been observed to burrow be-

neath the dirt in cloudy weather and remain thus many hours. This habit may be their method of maintaining their geographical position in time of flood. I have observed broad, sandy, barren flats where toad bugs lived become inundated by rapid currents of water for a few hours; nevertheless, when the water receded and the sun came again, here were the bugs as before. There were neither vegetation nor sizable stones for their anchorage, so I suppose they "dug in." They hop about with considerable alacrity when alarmed (one first instar nymph jumped ten inches). They pounce upon their prey, which appears to consist of almost any sort of insect they can capture, from a grouse locust (*tettix*) to a lacebug.

MATING.

There is considerable sexual dimorphism with the toad bug. The abdomen of the male is strongly asymmetrical, as is also the case in the male Corixidæ. Figures illustrating this are shown on plates IX and XXXII of SCIENCE BULLETIN, vol. XI. At that time no observations had been recorded on the mating. The male mounts the female, grasping her with the middle pair of legs, the first pair flexed beneath him, and the abdomen somewhat to the left side. This decided and invariable position to the left is due, of course, to the asymmetrical structure of the male genitalia. The frequency and duration of copulation of various pairs under observation is given herewith.

MATING OBSERVATIONS COVERING 25 DAYS.

DATE.	Pair 1.		Pair 2.		Pair 3.		Pair 4.		Pair 5.		Pair 6	
	Obs. mating.	Hrs. duration.	Obs. mating.	Hrs. duration.	Obs. mating.	Hrs. duration.	Obs. mating.	Hrs. duration.	Obs. mating.	Hrs. duration.	Obs. mating.	Hrs. duration.
May 15	X	4+	X	4+	X	4+	X	4+	X	4+	X	4+
May 17	X	6+	X	2+	X	4+	X	.....	X	6+	.....	.....
May 18	X	.....	X2	.....	.....	.....	X	.....	X	1	.....	.....
May 19	X2	2+	X	2+	X	2+	X2	4+, 2	X	1½	X	1+
May 20	X	2	X	2½+	.....	.....	X2	.....	.....	.....	X	6+
May 21	X	4½+	X	5+	.....	.....	X2	.....	X	4½+	X	2
May 22	X	.....	.....	.....	.....	.....	X	.....	.....	.....	X	.....
May 24	X2	.....	X	1	X	1¼	X	.....	X	.....	X2	.....
May 25	X	.....	.....	.....	X	.....	.....	.....	X	.....	.....	.....
May 27	X	.....	.....	.....	.....	.....	X	.....	X	.....	X	.....
May 28	X	.....	X	.....	X	.....	.....	.....	X	.....	.....	.....
May 29	.....	.....	X	.....	.....	.....	.....	.....	X	.....	.....	.....
May 31	X	.....	.....	.....	.....	.....	.....	.....	X	.....	X	.....
June 1	X2	.....	X	7+	.....	.....	.....	.....	X	1+	X	.....
June 2	X	3½	X	2+	X	4+	X	2+	X	2+	X	1½+
June 3	X	.....	.....	.....	X	6½	.....	.....	X	.....	.....	.....
June 4	.....	.....	X	.....	.....	.....	.....	.....	X	.....	.....	.....
June 7	X	.....	X	.....	.....	.....	X	.....	X	.....	.....	.....
June 9	.....	.....	.....	.....	.....	.....	.....	.....	X	.....	X	.....

In the table X signifies observed mating. If followed by the figure 2 it indicates two separate matings. The plus sign indicates that the bugs were mating when first or last observed, or both.

The above table indicates that the mating clasp may last as long as seven hours, that matings are frequent, often twice a day, and that they occur almost daily over a considerable period of time. Matings were observed in the laboratory from May to November.

OVIPOSITION.

The eggs are either completely or partly buried in the sand, cephalic end uppermost. The partly buried dry egg is white and very difficult to discover in dry sand. When it is moistened it changes to an amber or ferruginous, and with the sand takes on a deeper colored and glistening appearance, which further adds to its resemblance to a sand grain. A photograph of the egg upon a background of sand is shown on plate XIII. The number of eggs deposited by a female during the season must be 200 or more, because 192 nymphs and eggs have been recorded for one female, and it is quite likely that I did

not count the full complement. Oviposition continues throughout the season, the number of eggs laid per day varying from 1 to 13, from 2 to 6 being perhaps the average. A study of the hatching dates on the life-history tables will indicate the rate of egg-laying very well.

INCUBATION.

The incubation period varied from twelve to fifteen days. The red eyespots of the embryo are evident a number of days before hatching. The egg increases in size somewhat as the embryo develops, and the egg becomes darker with development.

HATCHING.

I was fortunate enough to observe the hatching process with the binoculars on several occasions, but never in as satisfactory lighting as I should have liked. The cephalic end of the egg shell splits longitudinally, squarely between the eyes, and extends back above the dorsum of the embryo. Through this rent a white, bulging body appears, resembling the bubble found above the head of *Corixa*. The front part of the head of the embryo pulsates rapidly. By slow straining heaves the embryo crowds out through the opening. Its body is as soft and pliable as a caterpillar. By bulging the fore part of the body and contracting the latter part, it worms its way to freedom—a creamy-white creature marked with two large, dark-red eyes, and with a body nearly cylindrical in shape and the thick limbs all most economically tucked away upon its venter. Then comes the postnatal molt, the casting of the shroud that binds the embryo. Standing erect upon its caudal end, its body encompassed and its limbs tied down by a diaphanous membrane that still holds it helpless to the empty casque in which it was formed, it struggles for freedom. First the membrane gives way above the head and emergence begins. As this skin slips back, the knob-like antennæ, which were directed downward along the beak, are free and change their position. Then the beak appears, and after slowly bending back and forward, one front leg pops out free, then the other. Finally all the legs are free, and the little bug settles down upon them, the shroud still about the tip of the abdomen. He flattens out into a toad bug, and after resting for a time, as if the birth struggles had been most exhausting, he suddenly becomes lively and starts away. Over the first moist pebble he passes, the molt is left, if by chance it did not remain fastened in the slit of the egg-shell. A period of thirty minutes often is consumed in the hatching. One bug that

hatched at 2:35 p. m. was creamy white with dark-red eyes at 3:12 p. m., when a faint pattern began to appear. At 3:35 it was somewhat darker and the pattern more distinct. Thus it takes an hour or so for it to attain its characteristic color.

MOLTING.

An examination of the life-history tables will indicate that mortality at molting time was very great in the rearings. This suggests that conditions were not favorable to normal molting. In the light of R. Takahashi's observations on the Ochteridæ, published in Japanese,* it may be that *Gelastocoris* nymphs, like those of *Ochterus formosanus* Mats., normally fashion for themselves small cells of sand above the ground in which the moltings take place. The sand in the rearing jars was packed, and perhaps too coarse for the nymphs.

The nymph becomes very plump of body along toward the time to change. Several first-instar bugs were under observation during the process of molting. The bug rests upon the sand, all legs outspread and apparently rigid. A longitudinal rent appears on the dorsum of the head and thorax, and the greenish or creamy-white nymph begins bulging out, the dorsal part of the thorax leading. Shortly the head is freed, the slit through the old skin extends back to the abdomen and then laterally to the margins of the body. These lateral fissures enable the bug to work his way out. The new form is so much larger than the old exuvium which encased it, that one wonders how it was ever tucked away in so small a space. When the new instar is entirely free, the old skin may snap back in place again and look like a perfect nymph, save that the eyes are whitish instead of dark red.

The following article appeared in Japanese, by R. Takahashi. The observations are so interesting, and relate to a family so little known, that English-reading students will be glad to give Mr. Takahashi credit for it.

These observations pertain to *Ochterus formosanus* (Mats.), which is not uncommon in Formosa.

1. The adults live upon the sandy shores of ponds and streams, where the colors of their backs merge into their surroundings, rendering them difficult to discover. They are not able to submerge and do not run out upon the water, where they are occasionally found by accident; but the nymphs are amphibious, being often seen submerged.

* R. Takahashi: "Observations on the Ochteridæ," Trans. Nat. Hist. Soc. Formosa, vol. XI, No. 55, pp. 119-125 (1921).

2. The adults are very active, while the nymphs are rather inactive. The death feigning has never been observed.

3. The species is not gregarious, but two or three nymphs are sometimes found in groups.

4. The nymphs sometimes vibrate the abdomen vertically for a few seconds when resting on the shore.

5. The nymphs cover their backs completely with sandy granules. All the nymphal instars have this habit. Their heads are provided on the front with 12 to 14 stout processes projecting forward and arranged in a transverse row, with which they scoop the sand upon the heads and push them backward by the front legs.

6. The nymphs construct for themselves small cells of sand above the ground, using the processes on the front, in which the moltings take place. All the instars have this peculiar habit.

7. The nymphs with the dorsums wettable are amphibious in habit, being often found submerged. When submerged, the bodies are held always just below the surface film, and they swim rather awkwardly, moving all the legs, but do not swim deeper. A store of air for respiration when submerged, is carried with the insect on the lower surface of the abdomen, and the nymphs now and then turn on their backs at the surface, thus exposing the lower surface of the abdomen into free air to take new supply of air. This is done very quickly.

8. The mating habit is almost as in the insects of *Microvelia,* but the males do not remain on the backs of their mates for a long time when the copulation is finished. The males and females mate repeatedly.

9. The eggs are singly placed upon the sandy granules, or upon the decayed leaves on the ground.

10. The egg is similar in shape to that of *Gelastocoris*, species figured by Doctor Hungerford (1919), measuring about 0.7 mm. in length.

11. There are five nymphal instars, as is common for other Heteroptera, and the nymphal stage lasts more than one month.

12. In the adults the front and middle tarsi are two-jointed, and the hind three-jointed, while in the nymphs all the tarsi are always two-jointed.

13. The adults may be seen near Taihoku at almost any time.

NOTES ON REARINGS.

FIRST PAIR.

Rearing Number 4.

This pair consisted of the female that I had kept in the laboratory all winter and a male selected from the spring shipment. They were confined in a six-inch stender in which had been placed a layer of sand with a place scooped out on one side for water. The water, however was taken up by the sand and the entire mass became water-soaked. To make a dry footing for the bugs, a bit of cork was set upright in the soil, but this too became wet. Green algæ covered the sand, the cork, the sides of the jar, and even the bugs were green with it. The surface of the sand was found on July 1

to be teeming with nematodes that were intent upon consuming the fly carcasses supplied as food for the bugs. No careful examination was made of this jar until July 1, when four white eggs were found on top of the cork, placed there in an endeavor, apparently, to keep them out of the wet, soggy sand. I then supplied dry sand to reduce the moisture, and on July 6 found eggs in the sand; observed mating on that date also. July 12 two nymphs hatched. July 20, there were several active first-instar nymphs. July 24, removed 18 dead first-instar forms and observed nine live ones. There were several eggs yet to hatch and some fresh eggs. July 27, removed two second-instar forms and took out 18 dead first-instar bugs. Seven live ones were observed at this time. July 30, observed a couple hatch and counted 10 active first-instar nymphs; also removed 7 dead ones. On August 1 there were nine live first-stage forms; removed 2 dead ones. August 2, counted 11 live first-stage bugs and removed 6 dead ones. On the 3d removed 2 dead ones. On the 4th there were 3 newly hatched bugs, and I removed 5 dead ones. On August 5 one first-instar bug was observed feeding upon another. August 7 there were at least 18 nymphs, three of them white, denoting recent hatching. August 8, 7 dead firsts were removed, but a dozen were still lively. August 9 another freshly emerged nymph was noted, and on the 10th 2 more. August 13, removed a second-instar form, and on August 15 another newly hatched was noted. August 16, a dark nymph was caught in the act of killing a white newly emerged brother. He was upon the back of his victim with beak inserted just back of the unfortunate's head. The latter was struggling, but to no avail. On August 18 one second-instar form was isolated and 34 dead first-stage bugs removed. Mr. Hoffman found three nymphs feeding upon their fellows, and all three victims were alive and kicking. There were about a dozen live bugs of this stage. August 21 brought forth 3 second-stage bugs, which were taken out. August 22, 11 dead firsts were moved, and on the 23d 3 dead firsts and 1 live second removed. August 24, 2 dead firsts were taken out. August 29, 5 dead first were removed, and on August 31 the female was found dead. Twenty-three dead nymphs were counted out and 8 eggs transferred to another stender. No live nymphs were present, and the jar was set aside till September 20, when a careful count was made of remains—10 eggs and 16 nymphs completed the record for this pair. The above notes have been given to show the result of trying to rear the bugs together.

This pair of bugs was observed mating May 15, 17, 18, 19, 20, 21, 22, 24, 27, June 2, 7, 22, and July 6. No count of eggs laid was attempted, but 22 eggs, 160 first-instar and 10 second-instar nymphs were taken, a total progeny of 192, with egg-lay noted from July 1 to last of August—this the performance of a female that spent the preceding winter in the laboratory.

REARING RECORD OF NO. 4.

No.	Date hatched.	1st molt.	2d molt.	3d molt.	4th molt.	5th molt.	Sex.	Days in stages.						Adult died.
								1st.	2d.	3d.	4th.	5th.	Tot.	
4a	July 12	July 21	Aug. 2	Aug. 15	Aug. 30	Sept. 19	♂	9	12	13	15	20	69	Oct. 6
4b	July 12	July 20	Died July 24	.....	.....	.....	....	8	4°	....	....	....	....	.....
4c	July 16	July 24	Aug. 13	Died Aug. 16	.....	.....	....	8	20	3°	....	....	....	.....
4d	July 16	July 25	Aug. 5	Aug. 16	Aug. 31	Sept. 23	♂	9	11	11	15	24	70	Nov. 17
4e	Aug. 1	Aug. 13	Died Aug. 31	.....	.....	.....	....	12	18°	....	....	....	....	.....
4f	Aug. 8	Aug. 18	Died Aug. 31	.....	.....	.....	....	10	13°	....	....	....	....	.....
4g	.....	Aug. 20	Sept. 10	Died Sept. 14	.....	.....	....	....	21	4°	....	....	....	.....
4h	.....	Aug. 21	Sept. 11	Sept. 20	Oct. 5	Died Oct. 20	....	....	21	9	16	15°	71?	.....
4i	.....	Aug. 21	Sept. 6	Sept. 17	Sept. 27	Oct. 26	♂	....	16	11	10	29	76?	Oct. 28
4j	.....	Aug. 23	Died Sept. 24	.....	.....	.....	....	....	1°	....	....	....	....	.....

° indicates "died" in this and following tables.

SECOND PAIR—OFFSPRING IN FOUR SERIES.

Rearing Number 1, Series m.

On July 6, Mrs. Wiley brought me 7 bugs from Chanute, which she had captured July 3. One pair, observed mating, I placed in a small stender on sand with a sprig of moss. July 8, quite a number of eggs were in the sand, so the adults were removed to another stender. On July 15, the eggs showed pink eyespots of the embryo within; and on July 19, 8 hatched and were isolated for rearing. July 21, 5 more hatched; and July 24, 3 more. Thus at least 16 eggs were laid by this female in two days, and the incubation period was 12 or 13 days. The rearing table marked 1m series is a record of fifteen of these nymphs.

Rearing Number 1, Series n.

The pair was transferred from 1m to this stender, containing sand, on July 8; observed mating on the 11th and removed on the 12th. Could find no eggs, and though this stender was studied till July 29, no nymphs appeared.

Rearing Number 1, Series o.

Transferred the pair from number 1n to this stender, containing sand, July 12. On July 24, 4 nymphs hatched, and so I removed the adults to another stender and transferred the nymphs to jars as they hatched. The rearing table marked 1o series indicates the dates of hatching. But to this list of 49 must be added the following: July 27, 6 first instars in large stender, labeled 10h. August 6, 4 dead instars; and August 8, 2 more. A total, therefore, of 61 hatched from eggs deposited between July 12 and 24, an average of 5 per day, with a record of 13 for August 6. Incubation period, 12 days.

Pair Number 1p.

This pair of adults was transferred from 1o on July 24. They were observed mating on this date and again on August 8, when 2 first-instar forms hatched. Removed the male on August 10 and returned on the 18th. This female was caught twice feeding upon her own offspring. Besides the 65 nymphs hatched from August 8 to September 27 and used in rearings, 28 dead ones were taken out of this stender in which the pair was confined—a total of 93 offspring between July 24 and September 27. The observed matings were on July 24, August 8, August 21 and September 20. One adult died October 4 and the other October 23. The rearing data are presented on that portion of the table marked IP series.

Summing up for this pair of bugs taken from the wild on July 3 and entered for observation on July 6, we get a total progeny of 170 hatched, and of this number we were able to rear to the adult stage 4 insects.

SECOND PAIR, REARING TABLE.

Series 1m.

No.	Date hatched.	1st molt.	2d molt.	3d molt.	4th molt.	5th molt.	Sex.	Days in stages.						Adult died.
								1st.	2d.	3d.	4th.	5th.	Tot.	
1ma	July 19	Died Aug. 14	.....	.....	.....	.....	....	26°	....	....	....	....	....	.....
1mb	July 19	Died Aug. 7	.....	.....	.....	.....	....	19°	....	....	....	....	....	.....
1mc	July 19	Aug. 11	Oct. 7	Died Oct. 25	.....	.....	....	23	27	19°	....	....	....	.....
1md	July 19	Aug. 6	Died Aug. 12	.....	.....	.....	....	18	6°	....	....	....	....	.....
1me	July 19	Died Aug. 5	.....	.....	.....	.....	....	17°	....	....	....	....	....	.....
1mf	July 19	Died Aug. 9	.....	.....	.....	.....	....	21°	....	....	....	....	....	.....
1mg	July 19	Died July 28	.....	.....	.....	.....	....	9°	....	....	....	....	....	.....
1mh	July 21	Aug. 1	Aug. 11	Died Aug. 16	.....	.....	....	11	10	5°	....	....	....	.....
1mi	July 21	July 28	Aug. 11	Died Aug. 16	.....	.....	....	7	14	5°	....	....	....	.....
1mj	July 21	Aug. 7	Died Aug. 11	.....	.....	.....	....	17	4°	....	....	....	....	.....
1mk	July 21	Died Sept. 12	.....	.....	.....	.....	....	53°	....	....	....	....	....	.....
1ml	July 21	Died July 30	.....	.....	.....	.....	....	9°	....	....	....	....	....	.....
1mm	July 21	July 25	Aug. 6	Aug. 15	Aug. 30	Sept. 19	♂	4	12	9	15	20	60	Nov. 4
1mn	July 24	Aug. 9	Died Aug. 10	.....	.....	.....	....	16	1°	....	....	....	....	.....
1mo	July 24	Died July 30	.....	.....	.....	.....	....	6°	....	....	....	....	....	.....

Series 1o.

No.	Date hatched.	1st molt.	2d molt.	3d molt.	4th molt.	5th molt.	Sex.	Days in stages.						Adult died.
								1st.	2d.	3d.	4th.	5th.	Tot.	
1oa	July 24	Aug. 11	Died Aug. 14	.....	.....	.....	....	18	2°	....	....	....	....	.....
1ob	July 24	Aug. 10	Died Aug. 13	.....	.....	.....	....	17	3°	....	....	....	....	.....
1oc	July 24	Died July 30	.....	.....	.....	.....	....	6°	....	....	....	....	....	.....
1od	July 24	Died July 31	.....	.....	.....	.....	....	7°	....	....	....	....	....	.....
1oe	July 25	Died Aug. 10	.....	.....	.....	.....	....	16°	....	....	....	....	....	.....
1of	July 25	Aug. 12	Sept. 2	Sept. 17	Died Oct. 1	.....	....	18	21	15	13°	....	....	.....
1og	July 25	Aug. 10	Died Aug. 14	.....	.....	.....	....	16	4°	....	....	....	....	.....
1oi	July 29	Died Aug. 8	.....	.....	.....	.....	....	10°	....	....	....	....	....	.....
1oj	July 29	Died Aug. 5	.....	.....	.....	.....	....	7°	....	....	....	....	....	.....
1ok	July 29	Aug. 13	Aug. 31	Sept. 13	Sept. 25	Oct. 21	♀	15	18	13	12	26	84	Dec. 20
1ol	July 29	escaped	.....	.....	.....	.....	....	....	....	....	....	....	....	.....
1om	July 29	Died Aug. 11	.....	.....	.....	.....	....	13°	....	....	....	....	....	.....
1on	July 29	Died Aug. 5	.....	.....	.....	.....	....	7°	....	....	....	....	....	.....
1oo	July 29	Died Aug. 10	.....	.....	.....	.....	....	12°	....	....	....	....	....	.....
1op	July 30	Died Aug. 7	.....	.....	.....	.....	....	8°	....	....	....	....	....	.....
1oq	July 30	Aug. 13	Sept. 15	Died Sept. 24	.....	.....	....	14	33	9°	....	....	....	.....
1or	July 30	Died Aug. 1	.....	.....	.....	.....	....	2°	....	....	....	....	....	.....
1os	July 30	Aug. 11	Aug. 28	Sept. 12	Sept. 24	Died Oct. 22	....	12	17	15	12	29	85	.....
1ot	July 30	Died Aug. 28	.....	.....	.....	.....	....	29°	....	....	....	....	....	.....
1ou	July 30	Died Aug. 8	.....	.....	.....	.....	....	9°	....	....	....	....	....	.....
1ov	July 30	Died Aug. 8	.....	.....	.....	.....	....	9°	....	....	....	....	....	.....
1ox	July 30	Died Aug. 9	.....	.....	.....	.....	....	10°	....	....	....	....	....	.....
1oy	July 30	Died Aug. 8	.....	.....	.....	.....	....	9°	....	....	....	....	....	.....
1oaa	Aug. 1	Died Aug. 9	.....	.....	.....	.....	....	8°	....	....	....	....	....	.....

Series 1o.—Concluded.

No.	Date hatched.	1st molt.	2d molt.	3d molt.	4th molt.	5th molt.	Sex.	Days in stages.						Adult died.
								1st.	2d.	3d.	4th.	5th.	Tot.	
1obb	Aug. 1	Aug. 18	Died Sept. 17	.....	.....	.....	....	17	30°	....	....	....	....	.....
1occ	Aug. 1	Died Aug. 8	.....	.....	.....	.....	....	7°	....	....	....	....	....	.....
1odd	Aug. 2	Died Aug. 10	.....	.....	.....	.....	....	8°	....	....	....	....	....	.....
1oee	Aug. 2	Died Aug. 9	.....	.....	.....	.....	....	7°	....	....	....	....	....	.....
1off	Aug. 2	Died Aug. 9	.....	.....	.....	.....	....	7°	....	....	....	....	....	.....
1ogg	Aug. 2	Died Aug. 9	.....	.....	.....	.....	....	7°	....	....	....	....	....	.....
1ohh	Aug. 2	Died Aug. 9	.....	.....	.....	.....	....	7°	....	....	....	....	....	.....
1oii	Aug. 2	Died Aug. 9	.....	.....	.....	.....	....	7°	....	....	....	....	....	.....
1ojj	Aug. 2	Died Aug. 9	.....	.....	.....	.....	....	7°	....	....	....	....	....	.....
1okk	Aug. 4	Died Aug. 10	.....	.....	.....	.....	....	6°	....	....	....	....	....	.....
1oll	Aug. 4	Died Aug. 14	.....	.....	.....	.....	....	10°	....	....	....	....	....	.....
1omm	Aug. 4	Died Aug. 9	.....	.....	.....	.....	....	5°	....	....	....	....	....	.....
1onn	Aug. 4	Died Aug. 9	.....	.....	.....	.....	....	5°	....	....	....	....	....	.....
1ooo	Aug. 5	Died Aug. 10	.....	.....	.....	.....	....	5°	....	....	....	....	....	.....
1opp	Aug. 5	Died Aug. 15	.....	.....	.....	.....	....	10°	....	....	....	....	....	.....
1oqq	Aug. 5	Sept. 12	Sept. 26	Oct. 21	Died Nov. 17	.....	....	38	14	25	27°	....	....	.....
1orr	Aug. 6	Died Aug. 11	.....	.....	.....	.....	....	5°	....	....	....	....	....	.....
1oss	Aug. 6	Died Aug. 10	.....	.....	.....	.....	....	4°	....	....	....	....	....	.....
1ott	Aug. 6	Died Aug. 13	.....	.....	.....	.....	....	7°	....	....	....	....	....	.....
1ouu	Aug. 6	Died Aug. 9	.....	.....	.....	.....	....	3°	....	....	....	....	....	.....
1ovv	Aug. 6	Died Aug. 12	.....	.....	.....	.....	....	6°	....	....	....	....	....	.....
1oww	Aug. 6	Died Aug. 14	.....	.....	.....	.....	....	8°	....	....	....	....	....	.....
1ozz	Aug. 6	Died Aug. 10	.....	.....	.....	.....	....	4°	....	....	....	....	....	.....
1oaaa	Aug. 6	Died Aug. 13	.....	.....	.....	.....	....	7°	....	....	....	....	....	.....
1obbb	Aug. 6	Died Aug. 11	.....	.....	.....	.....	....	5°	....	....	....	....	....	.....

Series 1p.

No.	Date hatched.	1st molt.	2d molt.	3d molt.	4th molt.	5th molt.	Sex.	Days in stages.						Adult died.
								1st.	2d.	3d.	4th.	5th.	Tot.	
1pa	Aug. 8	Died Aug. 14	.....	.....	.....	.....	....	6°	....	....	....	....	....	.....
1pb	Aug. 8	Died Aug. 14	.....	.....	.....	.....	....	6°	....	....	....	....	....	.....
1pc	Aug. 9	Died Aug. 14	.....	.....	.....	.....	....	5°	....	....	....	....	....	.....
1pd	Aug. 9	Died Aug. 15	.....	.....	.....	.....	....	6°	....	....	....	....	....	.....
1pe	Aug. 9	Sept. 22	Died Oct. 15	.....	.....	.....	....	44	23°	....	....	....	....	.....
1pf	Aug. 10	Died Aug. 18	.....	.....	.....	.....	....	8°	....	....	....	....	....	.....
1pg	Aug. 10	Died Aug. 16	.....	.....	.....	.....	....	6°	....	....	....	....	....	.....
1ph	Aug. 10	Died Aug. 19	.....	.....	.....	.....	....	9°	....	....	....	....	....	.....
1pi	Aug. 10	Died Aug. 19	.....	.....	.....	.....	....	9°	....	....	....	....	....	.....
1pj	Aug. 10	Died Aug. 17	.....	.....	.....	.....	....	7°	....	....	....	....	....	.....
1pk	Aug. 11	Died Aug. 12	.....	.....	.....	.....	....	1°	....	....	....	....	....	.....
1pl	Aug. 12	Died Aug. 25	.....	.....	.....	.....	....	13°	....	....	....	....	....	.....
1pm	Aug. 16	Died Aug. 22	.....	.....	.....	.....	....	6°	....	....	....	....	....	.....
1pn	Aug. 16	Died Aug. 22	.....	.....	.....	.....	....	6°	....	....	....	....	....	.....
1po	Aug. 16	Died Aug. 24	.....	.....	.....	.....	....	8°	....	....	....	....	....	.....
1pp	Aug. 16	Died Sept. 9	.....	.....	.....	.....	....	24°	....	....	....	....	....	.....
1pq	Aug. 16	Died Aug. 23	.....	.....	.....	.....	....	7°	....	....	....	....	....	.....
1pr	Aug. 16	Died Sept. 2	.....	.....	.....	.....	....	17°	....	....	....	....	....	.....
1ps	Aug. 17	Died Aug. 26	.....	.....	.....	.....	....	9°	....	....	....	....	....	.....
1pt	Aug. 17	Died Aug. 29	.....	.....	.....	.....	....	12°	....	....	....	....	....	.....
1pv	Aug. 18	Sept. 13	Died Oct. 6	.....	.....	.....	....	26	23°	....	....	....	....	.....
1pw	Aug. 19	Died Aug. 1	.....	.....	.....	.....	....	13°	....	....	....	....	....	.....
1px	Aug. 21	Died Aug. 2	.....	.....	.....	.....	....	12°	....	....	....	....	....	.....
1py	Aug. 21	Sept. 9	Sept. 23	Oct. 11	Died Oct. 23	.....	....	19	14	18	12°	....	....	.....

Series 1p—Continued.

No.	Date hatched.	1st molt.	2d molt.	3d molt.	4th molt.	5th molt.	Sex	Days in stages.						Adult died.
								1st.	2d.	3d.	4th.	5th.	Tot.	
1pz	Aug. 22	Died Aug. 11						20°						
1paa	Aug. 23	Died Aug. 4						12°						
1pbb	Aug. 25	Died Aug. 16						22°						
1pcc	Aug. 26	Died Aug. 29						3°						
1pdd	Aug. 27	Died Sept. 4						8°						
1pee	Aug. 28	Sept. 13	Died Sept. 24					16	11°					
1pff	Aug. 29	Sept. 15	Sept. 25	Oct. 14	Nov. 17	Died Nov. 26		17	10	20	34	9°		
1phh	Aug. 30	Died Sept. 9						10°						
1pii	Sept. 3	Died Sept. 17						14°						
1pjj	Sept. 4	Died Sept. 24						20°						
1pkk	Sept. 4	Died Sept. 15						11°						
1pll	Sept. 7	Died Sept. 9						2°						
1pmm	Sept. 7	Died Sept 15						8°						
1pnn	Sept. 9	Sept. 21	Oct. 15	Nov. 4	Died Dec. 4			12	24	20	30°			
1poo	Sept. 9	Died Sept. 18						9°						
1ppp	Sept 9	Died Sept. 17						8°						
1pqq	Sept. 9	Died Sept. 19						10°						
1prr	Sept. 10	Died Sept. 21						11°						
1pss	Sept. 12	Died Sept. 22						10°						
1ptt	Sept. 12	Died Sept. 26						14°						
1puu	Sept. 12	Died Sept. 21						9°						
1pvv	Sept. 12	Died Sept. 28						16°						
1pww	Sept. 12	Oct. 8	Died Oct. 12					26	4°					
1pxx	Sept. 12	Sept. 23	Oct. 11	Died Nov. 13				11	18	33°				

Series 1p—Concluded.

No.	Date hatched.	1st molt.	2d molt.	3d molt.	4th molt.	5th molt.	Sex.	Days in stages.						Adult died.
								1st.	2d.	3d.	4th.	5th.	Tot.	
1pyy	Sept. 13	Died Sept. 23						10°						
1pzz	Sept. 13	Died Sept. 21						8°						
1paaa	Sept. 13	Sept. 29	Died Nov. 2					16	3°					
1pbbb	Sept. 13	Died Sept. 28						15°						
1pccc	Sept. 15	Oct. 5	Nov. 2	Died Dec. 30				20	28	59°				
1pddd	Sept. 15	Died Sept. 25						10°						
1peee	Sept. 15	Sept. 27	Died Oct. 15					12	18°					
1pfff	Sept. 17	Died Sept. 30						13°						
1pggg	Sept. 17	Died Sept. 25						8°						
1phhh	Sept. 17	Died Sept. 19						2°						
1piii	Sept. 22	Died Oct. 2						10°						
1pjjj	Sept. 22	Died Sept. 28						6°						
1pkkk	Sept. 23	Died ?						?						
1plll	Sept. 23	Died Oct. 13						20°						
1pmmm	Sept. 23	Oct. 18	Died Oct. 30					25	12°					
1pnnn	Sept. 25	Died Sept. 29						4°						
1pooo	Sept. 27	Died Oct. 1						4°						

It was not planned when I began the studies to carry the rearings to such an extent and therefore the simple system of designating became cumbersome.

THIRD PAIR.

On May 14 I placed a pair in a small stender on the sand. Eggs showed eyespots June 2. June 10, 4 nymphs appeared, and on this date adult female died. The rearings from this pair are given in the following table:

No.	Date hatched.	1st molt.	2d molt.	3d molt.	4th molt.	5th molt.	Sex.	Days in stages.						Adult died.
								1st.	2d.	3d.	4th.	5th.	Tot.	
1b	June 10	June 28	Died July 17	.....	.....	.....	....	18	19°	....	....	.....	....	.....
1c	June 10	June 19	July 1	Escaped July 6	.....	.....	....	9	12	....	....	....	....	.....
1d	June 13	Died June 28	.....	.....	.....	.....	....	15°	....	....	....	....	....	.....
1e	June 13	Died June 21	.....	.....	.....	.....	....	8°	....	....	....	....	....	.....
1f	June 14	June 24	July 3	July 11	July 19	Aug. 2	♀	10	9	8	8	12	47	Jan. 11, 1921
1h	June 17	June 28	Died June 28	.....	.....	.....	....	11°	....	....	....	....	....	.....
1i	June 17	July 1	Died July 6	.....	.....	.....	....	14	5°	....	....	....	....	.....
1j	June 21	Died July 2	.....	.....	.....	.....	....	11°	....	....	....	....	....	.....
1k	June 21	June 28	July 6	July 15	July 22	Aug. 7	♀	7	8	9	7	16	47	Nov. 2
1l	June 22	July 5	July 15	July 23	Aug. 6	Aug. 31	♀	13	10	8	14	25	70	Oct. 10

FOURTH PAIR.

In a large stender containing sandy loam, and labeled No. 7, was placed a mating pair of bugs, June 28. Eggs were discovered in the soil on July 8. July 13 nymphs hatched and the adults were removed. July 20, 7 more nymphs were out. These 12 nymphs were isolated in stenders and a tabular report of these follows. The incubation period was somewhere between 7 and 15 days.

No.	Date hatched.	1st molt.	2d molt.	3d molt.	4th molt.	5th molt.	Sex.	Days in stages.						Adult died.
								1st.	2d.	3d.	4th.	5th.	Tot.	
7a	July 13	Escaped	.....	.....	.....	.....	....	.....	.....	.....	.....	.....	.....	.....
7b	July 13	July 20	Died July 23	.....	.....	.....	....	7	3°	...	....	....	....	.....
7c	July 14	July 21	Aug. 6	Died Aug. 14	.....	.....	....	7	16	8°	....	....	....	.....
7e	July 14	Died July 23	.....	.....	.....	.....	....	9°	....	....	....	....	....	.....
7f	July 20	Died July 30	.....	.....	.....	.....	....	10°	...	....	....	....	....	.....
7g	July 20	July 28	Aug. 6	Aug. 16	Sept. 1	Sept. 21	♀	8	9	10	16	20	63	Oct. 28
7h	July 20	Aug. 16	Aug. 30	Sept. 12	Sept. 22	Oct. 17	♂	27	14	13	10	25	89	Nov. 14
7i	July 20	Aug. 4	Aug. 14	Aug. 26	Sept. 11	Sept. 29	♂	15	10	12	16	18	71	Nov. 21
7j	July 20	Aug. 9	Died Aug. 12	.....	.....	.....	....	20	3°	....	....	....	....	.....
7k	July 20	Died July 28	.....	.....	.....	.....	....	8°	...	....	....	....	....	.....
71	July 31	Aug. 6	Aug. 16	Sept. 14	Died Sept. 27	.....	....	6	11	29	13°	....	....	.....

FIFTH SERIES.

A sprig of moss and earth containing eggs were placed in a stender July 12. These eggs were deposited by bugs sent me July 6, amongst the material in which they were packed. They began hatching July 20 and finished July 24. The record of the eight nymphs isolated is shown in tabular form below.

No.	Date hatched.	1st molt.	2d molt.	3d molt.	4th molt.	5th molt.	Sex.	Days in stages.						Adult died.
								1st.	2d	3d.	4th.	5th.	Tot.	
9a	July 20	July 30	Aug. 19	Sept. 15	Oct. 7	Died Oct. 18	....	10	20	27	22	11	....	.....
9b	July 20	Aug. 6	Aug. 18	Aug. 30	Sept. 13	Oct. 5	♂	17	12	12	14	22	77	Oct. 17
9c	July 21	Aug. 2	Died Aug. 10	.....	.....	.....	....	12	8	....	....	....	....	.....
9d	July 21	Died July 31	.... ..	. ...	... .	.....	....	10	....	....	....	....	....	.....
9e	July 24	Died Aug. 9	.... ..	.. ..	... .	.....	....	16	....	....	....	....	....	.....
9f	July 24	Died Aug. 3	.....	.....	.....	.....	....	10	....	....	....	....	....	.....
9g	July 24	Aug. 1	Died Aug. 9	.....	.....	.....	....	8	8	....	....	....	....	.....
9h	July 24	July 30	Aug. 15	Sept. 9	Sept. 22	Died Oct. 14	....	6	16	25	13	22	....	.....

SIXTH PAIR.

Placed 2 female bugs in large stender marked No. 12, on July 20. These bugs were from those Mrs. Wiley collected July 3. On August 2, 2 nymphs appeared—an incubation period of 13 days. The nymphs continued to appear, and their record is shown in table 12 below. September 5 only 1 adult was to be found, and yet it was impossible for the bugs to escape from the jar. September 6 both were gone from view, but later they were again above the sand. In cloudy, threatening weather, the toad bugs bury themselves beneath the surface and appear again in sunny weather.

Table 12.

No.	Date hatched.	1st molt.	2d molt.	3d molt.	4th molt.	5th molt.	Sex.	Days in stages.						Adult died.
								1st.	2d.	3d.	4th.	5th.	Tot.	
12a	Aug. 2	Died Aug. 8						6						
12b	Aug. 2	Died Aug. 9						7						
12c	Aug. 8	Died Aug. 14						6						
12d	Aug. 9	Died Aug. 14						5						
12e	Aug. 10	Died Aug. 12						2						
12f	Aug. 10	Aug. 26	Died Sept. 17					16	22					
12g	Aug. 11	Died Aug. 19						8						
12h	Aug. 15	Died Aug. 21						6						
12i	Aug. 15	Died Aug. 22						7						
12j	Aug. 16	Died Aug. 28						12						

SEVENTH PAIR.

In stender marked 2a, placed a mating pair on May 25. On June 3, found an egg imbedded in the sand for about one-half of its length. On June 13, found 11 eggs, 5 or 6 of which showed pink eye-spots, so removed the adults to another stender. The eggs began hatching June 17 and continued until June 28. The minimum incubation period for some of the eggs was 15 days.

EIGHTH PAIR.

Pair from Chanute placed in stender labeled 1a, June 2. The female died June 10. Eggs hatched June 24 and June 28. Incubation period at least 14 days, likely longer.

NINTH PAIR.

Female emerged from one of the rearings (1l) on August 31, from a nymph that hatched June 22. Added a male, but no mating observed, and female died October 10.

TENTH PAIR.

Female emerged from one of the rearings (1k) on August 10, from nymph that hatched June 21. Placed a male with her and matings were observed on August 13, 15 and 18. No eggs were found after most thorough search. Female died November 4.

DESCRIPTION OF STAGES.

(See plates XIII and XIV.)

THE EGG.

Size. Length, 1.25 mm.; diameter, .91 mm.

Shape. Broadly oval. The surface is roughly granular and marked into regular hexagonal areas by thickened ridges of the chorion.

FIRST-INSTAR NYMPH.

Size. Length, 2 mm.; width of thorax, 1.4 mm.; width of head, 1.2 mm.

Color. Eyes dark; body mottled to checkered obscurely, general color sometimes light, sometimes dark. Legs and abdomen are usually marked as described for later instars.

Structural peculiarities. Eyes larger relatively than in succeeding instars. They are not placed upon as high elevations and the inner emarginations are not marked. The beak is four-segmented; the antennæ three-segmented; and the tarsi appear one-segmented, terminating in two claws. The middle and hind tarsi, however, have a short basal segment, making two. Lateral margin of mesothorax less in length than that of metathorax.

SECOND-INSTAR NYMPH.

Size. Length, 2.5 mm.; width of thorax, 1.9 mm.; width of head, 1.5 mm.

Color. Eyes still dark, not distinctly banded. Pattern obscured, that of limbs and abdomen as in later instars.

Structural peculiarities. The inner emargination of the eyes a little more marked than in the preceding instar. Lateral margin of mesothorax equal in length to that of metathorax.

THIRD-INSTAR NYMPH.

Size. Length, 3.5 mm.; width of thorax, 2.7 mm.; width of head, 2.0 mm.

Color. The eyes faintly banded with three bars of color, one of them on the inner margins. The general pattern variable; but when defined, like other instars.

Structural peculiarities. The inner emargination of the eye now regular and marked. Ocelli faintly visible in some, while in others unmistakably present. Lateral margin of Mesothorax now a little longer than that of metathorax.

FOURTH INSTAR NYMPH.

Size. Length, 4.5 mm.; width of thorax, 3.6 mm., width of head, 2.4 mm.

Color. The general pattern as in fifth. The eyes banded by four faint bars, one of which is on inner margin.

Structural peculiarities. The lateral margin of mesothorax now is about twice as long as that of the metathoracic margin, due, of course, to the lengthening of the wing pads. The body is covered with closely set short, stout, appressed spines, which show more plainly than in the preceding instar. The ocelli show plainly now. They are located just above the lateral arms of what I take to be the epicranial suture. The nymphal exuvium always shows a Y-shaped rent on the head, and it is on the upper margin of the lateral arms of this fissure that the ocelli are located.

FIFTH INSTAR NYMPH.

Size. Length, 6.2 mm.; width of thorax, 5.0 mm.; width of head, 3.0 mm.

Color. Color variable from very light to very dark, and the pattern varying from obscure to distinct. The eyes have five dark bars. There are two pairs of black dots on the face, one above the other, and laterad and below the ocelli. A median black dot on vertex. The pronotum has front two-thirds of lateral margins of prothorax darker. There is a pair of black spots caudo-laterally of each pronotal elevation, of which there are two. The mesonotum has two rectangular black spots on front margin either side of median line. There is a transverse row of four black dots across caudal third of mesonotum; wing pad has a dark rectangular spot on shoulder; the middle of the pad crossed by another dark area; tip and inner margin of pad dark. Two faint dark irregular spots in the outer third of wing pad gives a mottled effect to the whole. A white spot is found on second abdominal segment either side of median line. A row of dark marginal spots, roughly triangular, cover the front two-thirds of the margin of each abdominal segment. There are also two rows of dark submarginal spots, faint and ill defined. The legs are banded with dark bands. The hind tibiæ have three dark bands besides being dark at the ends.

Structural peculiarities. The wing pads of the mesothorax now extend almost to caudal margin of thorax, nearly obscuring lateral margin of meta-thorax.

SUMMARY.

The toad bug places its eggs in the sand. The eggs hatch in about 12 days. There are five nymphal instars. Forty-nine first-instar bugs transformed in an average of 15 days (the shortest time 4 days and the longest 44 days). Thirty-three second-instar bugs transformed in an average of 16 days (shortest time 8 days and longest 33 days). Twenty-two third-instar bugs averaged 15 days (the shortest time 8 days and the longest period, not counted in the average because it failed to molt, was 59 days). Eighteen fourth-instar forms averaged 15½ days (minimum 7 days and maximum 34 days). Thirteen fifth-instar forms averaged 22 days (minimum 12 and maximum 29 days). The average number of days for the thirteen adults to develop from the hatching to emergence was 70½ days. The shortest period was 47 days and the longest 89 days. By adding the 12 days incubation of the egg, we get a total development period of from 60 to 100 days. The adult female may deposit a dozen eggs a day, but would average perhaps only 2 to 6 over the period of two or more months. One hundred and ninety-two eggs and nymphs were counted from one female from July 6 to September 27. The nymphs possess ocelli, plainly distinguished as early as the third instar. All the stages are predaceous and much like their parents in other habits as well.

PLATE XIII.

Gelastocoris oculatos Fabr.

FIG. 1. Adult bug (not *oculatus,* but an undescribed species in western Kansas) upon sand, showing how its mottled pattern makes it difficult to discern.

FIG. 2. Ventral view of above species of bug. Enlarged photograph showing the bug clasping three lace bugs.

FIG. 3. First-instar nymph, *Gelastocoris oculatus* Fabr. Enlarged dorsal view, same species shown in figures 1 and 2.

FIG. 4. Another toad bug. Enlarged ventral view, showing bug with prey.

FIG. 5. First-instar nymph, *Gelastocoris oculatus* Fabr., ventral view.

FIG. 6. Microphotograph of egg and first-instar nymph. Nymph in center of picture and the white oval egg to the right of it. The egg resembles the sand grains very closely.

PLATE XIII.

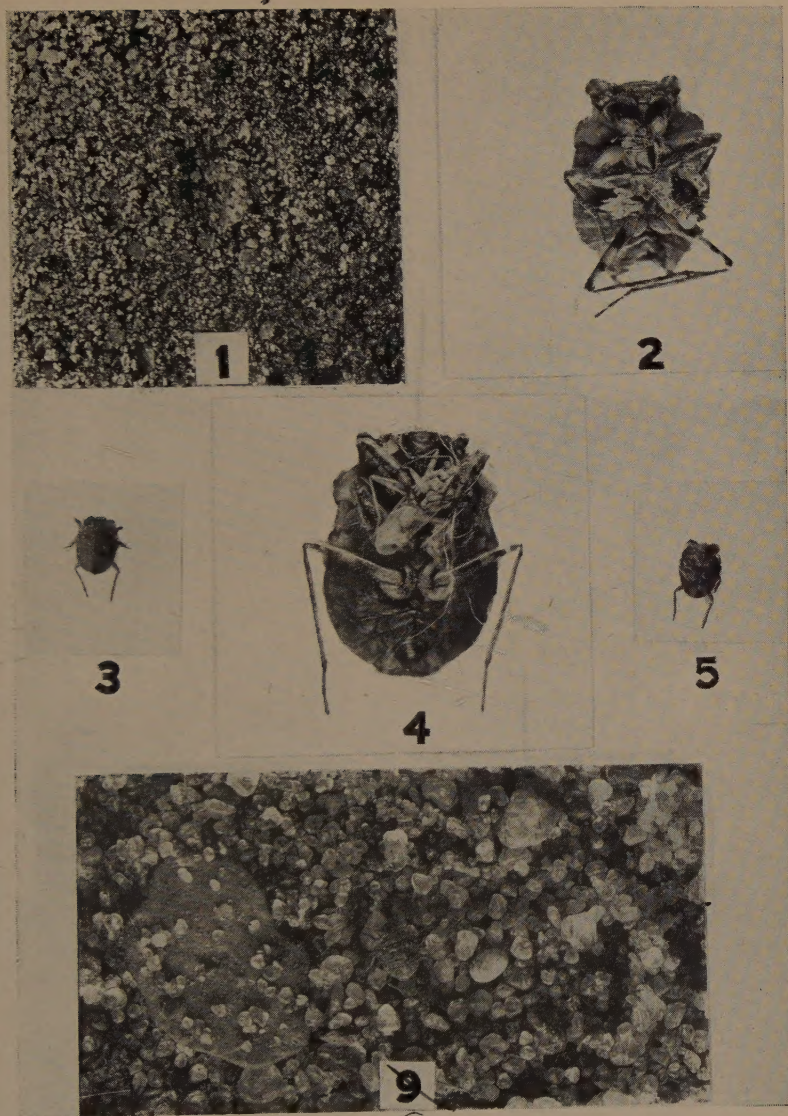
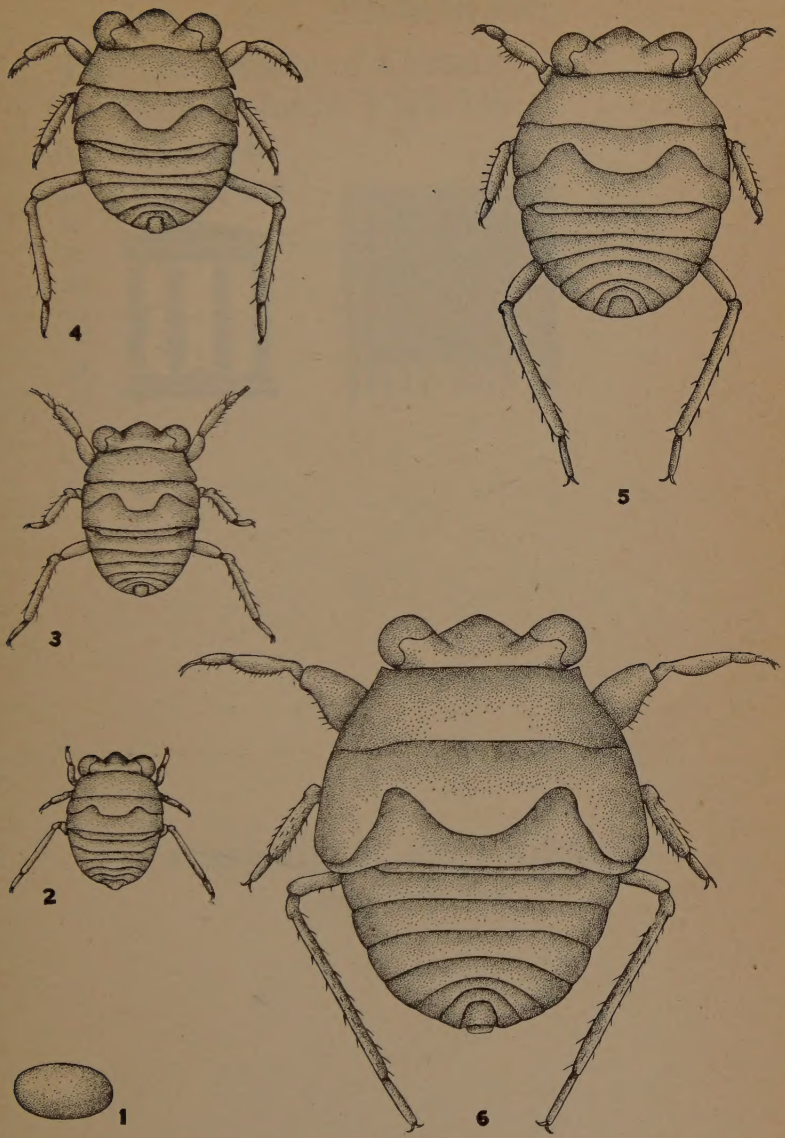
PLATE XIV.